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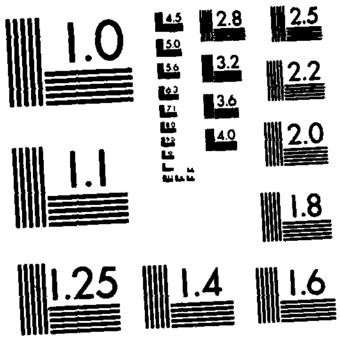
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TRANSLATION DIVISION NISC-62
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AUTHOR: V. LOGACHEV

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THE NEUTRON WEAPON--PECULIARITIES OF THE CONSTRUCTION AND DESTRUCTIVE EFFECT

[Logachev, V.; Neutronwaffe--Besonderheiten des Aufbaus und der Vernichtungs-wirkung; Militaertechnik, No. 4, 1978, pp. 218-220; German]

The political discussion against the production of neutron weapons in the U.S. and their introduction into NATO is spreading worldwide and becoming more pronounced. Therefore, the editor considers it important to again present the technical aspects of this spectacular weapon from the viewpoint of a Soviet writer. /21*

The article by Colonel K. Langhans in Militaertechnik, No. 2, 1978, pp. 91-94, could not review the following article by V. Logachev. Fortunately, the views of both writers coincide on all major points. We feel the reprint of the following article is justified, based on various important military-technical viewpoints. In the main, it further amplifies previous data on presumed nuclear reactions in neutron weapons, the division of energy components in fission, fusion, and combined nuclear weapons into various efficiency factors, as well as the kill radii with various detonation intensities.

Several ideas in the article could also generate further discussion. For instance, reference to the reduced overall munitions requirements, based on the detonation intensity of neutron weapons versus small nuclear fission weapons, is essentially proper, but in view of the costs and possibly also the weight of each warhead, or the size of the engaged target area, the ratio may be reversed.

The very cautious observation that "there are currently no portable protective shields against fast neutrons and hard gamma radiation" should not lead one to hope that this problem, which has existed for years and is unreconcilable with the natural laws we have been aware of until now, will be solved within the next few years.

The editorial revision of the article included a number of clarifying explanations and terminology. For instance, the term "neutron bomb" was replaced with the militarily more appropriate term "neutron weapon". The energy sources in Table 1--as previously customary and quite correct--were not translated as "destruction factors", since the concurrent heat of the "detonation cloud" ostensibly does not have a destruction factor, though it may still be designated as an efficiency factor.

And here just one more personal note: In the article by LANGHANS (Militaertechnik, No. 2, 1978, Fig. 2) lithium hydride is cited as the presumed nuclear fission explosive. Due to printing problems, one correction desired by the author, the term "deuterium tritium," could only be inserted in the text (see p. 92). Even Logachev, with a corresponding observation, likewise corroborates the inappropriateness of lithium compounds for neutron weapons.

The Editor

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*Numbers in right margin indicate pagination in original text.

In the foreign press, neutron weapons with a TNT equivalent of up to 10 kt are designated nuclear weapons. In such a weapon, nuclear fusion reactions are used, in which a small nuclear fission charge is presumably required for detonation.

The ratio of the energy released through the nuclear fusion reactions in relation to the total detonation energy is expressed by the nuclear reaction ratio K_z. In the case of neutron weapons, K_z ranges from 0.90 to 0.95.

The first generation of tactical nuclear weapons contained nuclear fission charges from the nuclear explosives uranium 235 or plutonium 239. The latter was used in very small nuclear weapons, since it has a much smaller critical mass that uranium 235.

Upon detonation of the nuclear fission charge, most of the energy (about 85%) is borne by nuclear fragments which fly apart in all directions. These relatively large nuclear particles are slowed down by the air, resulting in light emission and air compression. The destructive factors -- light radiation and a pressure wave--are developed. The effects on humans and equipment are being thoroughly researched and described.

During nuclear fusion, energy is released mainly as a flux of fast neutrons, and only to a minor extent involving their type of radiation. Thus, for the most part, very small nuclear expolosives involving nuclear fusion are designated neutron weapons.

The distribution of energy upon detonation of a nuclear explosive in compressed air depends essentially upon the type of generation. Table 1 shows the energy components in percentages. One may conclude there fromthat with a combined nuclear charge, in which both nuclear fission and fusion occur, and assuming equal TNT equivalents, along with an increasing nuclear reaction ratio, /219
the penetrating radiation as a destruction factor will increase. At a K_z of 0.90 to 0.95, the effects of nuclear radiation will be considerably higher that the destruction area for the pressure wave at a force of at least 10 kt. TNT equivalent.

It should also be noted that the various data contained in Table 1 (for example, pressure and light distribution) are significantly dependent upon the properties of the external medium (for example, light density). Thus they vary with increasing altitude of detonation. Thus the amount of energy for the penetrating radiation is not dependent upon air density. Detonations at altitudes of 40 to 60 km, for example, emit X-rays, which are capable of affecting the ability of cosmic objects to function. The energy released from the nuclear fusion of a 1-kg mixture of deuterium and tritium corresponds to a detonation equvalent of 80 kt of TNT. This reaction requires extreme conditions. In order to initiate it, the nucleii must be brought very close together. Under normal conditions, the electron shell of the atoms will not permit this. However, if the electrons are shoved aside (which corresponds to the plasma state of the substance), Coulomb repelling forces with the same charge operate. Only a very high velocity of the nucleii can overcome these repelling forces. It increases as the temperature of the substance increases.

Nuclear fusion reactions become possible only at temperatures above several hundred million degrees Centigrade. They are designated as thermonuclear reactions.

The development of a device to initiate a thermonuclear reaction in a neutron weapon was a very complicated task. The possible construction of a detonator received differing treatment from the press. Most writers feel that a compact nuclear fission detonator can be constructed from highly-enriched p'utonium 239. When transplutonium elements are added, it could have a critical mass of about 1 to 3 kg. The energy released by the nuclear fission detonator must be, on the one hand, minimal, but, on the other hand, sufficient to trigger nuclear fusion.

Accordingly, larger amounts of weapons-grade plutonium are necessary for the production of neutron weapons. The amounts currently produced in the U.S. are not sufficient for this purpose. Production should be increased. For this purpose, the U.S. 1979 Fiscal Year budget includes about 12 million. The new generation of tactical nuclear weapons includes mixtures of deuterium $^{2}_{1}H(D)$ and tritium $^{3}_{1}H(T)$. The following synthesis reactions occur therein, in which neutrons with great energy are released:

$$D + T \rightarrow {}^{4}_{2}He + n + 17{,}6\ MeV,$$

$$D + D \rightarrow {}^{3}_{2}He + n + 3{,}25\ MeV,$$

$$D + D \rightarrow T + {}^{1}_{1}H + 4\ MeV,$$

$$T + T \rightarrow {}^{4}_{2}He + 2n + 11{,}3\ MeV.$$

Calculations have determined that the reaction between deuterium and tritium is the easiest to achieve. It can occur at a temperature of about 25 million degrees Centigrade and with a velocity sufficient for detonation. In the process, the neutrons transfer about 70 to 80% of the energy (up to 14 MeV per neutron), the helium atoms 18 to 28%, and the γ quanta about 2%. At a temperature of 300 to 350 million degrees C, reactions may occur between D + D and T + T, in which two fast neutrons are produced.

Obviously, tritium is used in weapons in a pure form or as a compound. It would be inappropriate to wait to extract tritium from nuclear reactions in a neutron weapon, since this, for example, involves a heavy use of neutrons and would reduce the effect of the neutrons expanding outwards:

$$Li + n \rightarrow T + {}^{4}_{2}He + 4{,}8\ MeV.$$

Tritium and deuterium can be used in the charge as solids in the form of a metal hydride or in a compressed gaseous state. In order to achieve the smallest or reduced detonation forces, relatively small amounts of tritium and deuterium are necessary (see Table 2). Fig. 1 shows a hypothetical sketch of the construction of a nuclear artillery charge with amplified neutron radiation, i.e., a neutron shell. Experts do not doubt that there are other design solutions for improving the ignition mechanism for the thermonuclear reaction. In particular, an implosion can bring the plutonium 239 in the nuclear fission detonator to a supercritical mass.

There has already been speculation in the press that the next generation of tactical nuclear weapons will use a so-called nonnuclear process to initiate nuclear fusion. This could be, for example, lasers, electron or ion accelerators, and the like. Within the next 5 to 10 years, the U.S. hopes to develop and introduce the following tactical weapons:

-nuclear weapons with strong penetrating radiation and a weak wave (neutron weapons);

-nuclear weapons with a stronger pressure wave for the destruction of missile pads, command post, particularly important installations, and other targets;

-nuclear weapons with strong radiation doses, with which special radioactive agents can be formed under the influence of neutrons; and

-conventional (nonnuclear), large-caliber ordnance.

It is believed that the U.S. will introduce the new tactical nuclear weapons system after 1979/80. First to be introduced will be neutron weapons in the form of 203.2-mm shells weighing 90 kg and with a length of 892 mm, as well as warheads for the LANCE missile, weighing 205 kg and with a maximum diameter of 560 mm. As already indicated, its principal destruction factor is its penetrating radiation. Foreign experts are of the opinion that the effective destruction radius of the penetrating radiation is that distance from the detonation point at which total incapacitation of the troops will be achieved in 10 to 30 min. A dosage of about 5000 rads will be necessary to achieve this biological effect.

In the case of a neutron weapon, the nuclear radiation dose is 5 to 10 times stronger than that from a nuclear fission weapon of the same detonation intensity and the same distance from the point of detonation. The approximate values for the destruction zones are shown in Table 3.

The effective radii "R" of nuclear weapon detonations with increased neutron radiation may be calculated for nuclear weapons according to the following formula:

$$R_{ds_N} = R_{ds_S} \cdot K_z + R_{ds_T}(1 - K_z), \qquad (1)$$

$$R_{DW_N} = R_{DW_S} \cdot K_z + R_{DW_T}(1 - K_z). \qquad (2)$$

in which:

ds = penetrating radiation, DW = pressure wave, N = neutrons, S = fusion, T = separation (fission).

At a K_z of .90 to .95, the dimensions for the zones in which personnel will be killed by the penetrating radiation differ little from the values in Table 3 for fusion charges. It is obvious from the table that, for the same detonation

intensity, utilizing the energy from fusion reaction, the radius of the area in which unprotected personnel can be put out of action is double that of a fission charge. Therefore, the amount of munitions required to complete the combat mission can be reduced. In addition, the area of the destruction zone resulting from the penetrating radiation is 12 to 70 times larger that that of the destruction zone resulting from the pressure wave. It should also be /220
noted that radiation injuries and casualties will occur even beyond the zones shown in Table 3. Through the formation of a definite quantity of nuclear fission products, depending upon the type of ignition, and as a result of the activation of elements in the earth through neutrons, within the detonation area a small radioactive zone and a narrow radioactive belt extending for several kilometers can arise. For all practical purposes, one can disregard activation of the terrain, the pressure wave and the light radiation in the detonation of a neutron weapon. The induced activity in the construction materials of the weapons and combat equipment, particularly in high-alloy steels, will represent, for a more extended period of time, a real danger for those personnel engaged in eliminating the effects of enemy nuclear weapon strikes. The biological effect of the neutrons on the human organism depends upon the energy of the neutrons. In the materials which they penetrate, fast neutrons ($.5 \text{ MeV} < E_n < 10 \text{ MeV}$) form so-called recoil nucleii. Of greatest importance are collisions between neutrons and hydrogen nucleii (protons), which have similar mass and thus, at the moment of collision, can receive the entire neutron energy. In addition, hydrogen constitutes 2/3 of the atoms in living tissue. The energy received from the protons is used for ionization of the atoms. This leads to the destruction of molecular compounds in living cells. Due to release of γ quanta, the slow neutrons are captured by the nucleii. Thus the effect of the neutron flux on a human is similar to the γ radiation on the ionization of tissue atoms, whereby the biological effect is totally determined by the level of exposure.

Human protection from new tactical weapons primarily involves the search for effective methods of attenuating the neutron flux and the related establishment of neutron radiation measurement. Effective neutron absorbers are hydrogenous substances (water, parafin, polyethylene, etc.). Substances containing boron can be used as protection against slow neutrons. For all practical purposes, thermal neutrons can be absorbed completely by a layer of cadmium 1 mm thick.

However, neutron absorbtion causes secondary γ radiation. So far, it has not been possible to construct portable means of protection from fast neutrons and hard γ quanta. For personal protection in combat vehicles and other vehicles, foreign experts suggest the use of multiple layers of such materials as boron and cadmium. Building materials (concrete, wood, earth, etc.) have sufficiently good protective qualities. A concrete wall 20 cm thick weakens the neutron flux by about 80%.

Table 1. Energy distribution upon detonation of a nuclear explosive in compressed air (according to foreign data)

Efficiency factors	Energy Composition in %	
	Fission weapons	Fusion weapons
Pressure wave	35	8
Light radiation	35	8
Penetrating radiation	5	70
Radioactive decay	6	-
Electromagnetic pulse	less than 1	less than 1
Temperature of the detonation cloud	19	14

Table 2. Masses for calculating the D + T mixture and tritium, required for nuclear explosive charges of various detonation forces

TNT equivalent, in t	10	20	50	100	200	500	1000	10,000
Mass of the D + T mixture, in g	.13	.3	.7	1.3	2.5	7	13	130
Tritium mass, in g	.08	.2	.4	.8	1.5	4	8	80

Table 3. Radii of the zones in which personnel out in the open will be killed upon exposure to penetrating radiation of 5000 rads and a pressure of 50 kN/m^2

	Nuclear fission charge			Nuclear fusion charge		
TNT equivalent, in t	Radius of penetrating radiation R_{dS}, in m	Radius of the pressure wave R_{DW}, in m	Ratio of the surface areas of the destruction zones, F_{dS}/F_{DW}	Radius of penetrating radiation R_{dS}, in m	Radius of the pressure wave R_{DW}, in m	Ratio of the surface areas of the destruction zones, F_{dS}/F_{DW}
10	150	50	9:1	300	35	70:1
20	170	70	6:1	360	50	50:1
50	230	120	4:1	470	80	35:1
100	280	170	3:1	550	100	32:1
200	330	230	2:1	650	120	29:1
500	400	320	1.5:1	800	150	28:1
1000	470	420	1.2:1	950	200	23:1
10000	770	950	0.7:1	1400	400	12:1

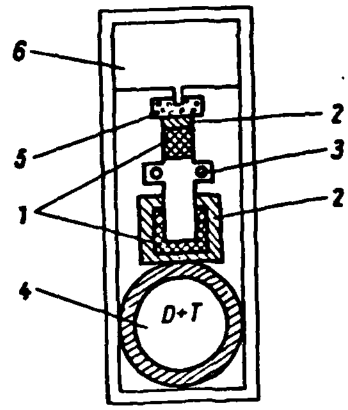

Fig. 1. A possible variation in the construction of a neutron weapon

1) Plutonium 239; 2) Neutron reflectors; 3) Neutron sources to initiate the fission reaction; 4) Mixture of deuterium and tritium; 5) Conventional explosive charge; 6) Device for timely ignition of the charge.